

SPECIFICATION

Scroll Compressor and Method for Machining Scroll Wrap

TECHNICAL FIELD

5 The present invention relates to a scroll compressor used for a refrigerating apparatus, an air-conditioning apparatus or the like, and a method for machining a scroll wrap.

BACKGROUND ART

10 A scroll compressor mainly has a structure shown in Fig. 12 and Fig. 13. Stationary scroll (hereinafter referred to as scroll) 52 and slewing scroll (hereinafter referred to as scroll) 53 are respectively shaped such that scroll-like wraps 50 and 51 are raised from end plates 52A and 53A so as to be substantially perpendicular
15 to the end plates. In scroll 52 and scroll 53, wraps 50 and 51 are engaged to each other to have compression space 54 therebetween. A capacity of compression space 54 is decreased by a circular orbit motion of scroll 53 while compression space 54 moves from an outer circumference leading to inhale opening 55 to a center part
20 leading to discharge opening 56. Thus, fluid is inhaled, compressed, and discharged.

 Scrolls 52 and 53 are made by metal mainly of iron or aluminum. After they are formed by a casting or the like, side faces of wraps 50 and 51 sliding to each other are finished by being
25 cut by end mill 57 having 2 to 10 cutting blades. In this manner, a required performance is secured.

 Methods for finishing an involute curve-shaped scroll wrap

by an end mill are disclosed by Japanese Patent Unexamined Publication No. H04-284509, Japanese Patent Unexamined Publication No. H07-164231, and Japanese Patent Unexamined Publication No. 2000-205155, for example. According to these
5 publications, the feed rate of the end mill is controlled depending on the curvature radius of the involute curve. Any of these methods secures the plane roughness of a machined face.

However, in the case of the cutting and finishing by the machining by end mill 57 of wraps 50 and 51 having the above
10 conventional structure, the side walls of wraps 50 and 51 have an accuracy that depends not only on the machining accuracy of end mill 57 but also on a runout due to an error at which end mill 57 is attached, and on the machining conditions. Thus, it is difficult to secure and manage a favorable accuracy in a stable manner, causing
15 a poor surface roughness. In order to prevent the leakage of compressed gas by reducing the clearance between the side faces while scrolls 52 and 53 are engaged to each other, it is necessary that the dimensional accuracies of the side faces are improved.

Furthermore, each of end plates 52A and 53A has a large
20 surface roughness because they are cut by end mill 57 together with the side faces of wraps 50 and 51, thus causing a sharp tip end at each convex at the surface roughness. This causes a sliding loss and a leakage loss of compressed gas, causing the efficiency of the compressor to be insufficient and to deteriorate easily.

25 Furthermore, the machining by end mill 57 is generally performed with the number of rotations of 20,000 in order to suppress the abrasion of the blade edge. Thus, in order to secure

the machining efficiency, the feed amount per one rotation needs to be increased. If the feed amount per one rotation is increased, uneven machining is caused in a regularly-repeated manner due to the existence of a part of end mill 57 having the cutting blade and a part having no cutting blade. This uneven machining is caused with a pitch inversely proportional to the number of the cutting blades. Furthermore, an error caused when end mill 57 is attached also causes a regularly-repeated runout, causing swells in the longitudinal direction of the side faces of wraps 50 and 51. These swells cause minor vibrations in scroll 53 while the compressor is being operated, thus increasing noise.

Furthermore, when corners of side faces of wraps 50 and 51 and corners of end plates 52A and 53A at the boundary have abrasion when being slid with the corner of the tip end of the outer circumference of end mill 57, the shapes of corners of side faces of wraps 50 and 51 and the shapes of corners of end plates 52A and 53A are changed. In consideration of this, the inner and outer corners of the upper end face of an upper wrap engaged with a lower wrap need to be chamfered in a large amount and thus a space provided therebetween is increased. This increases the leakage of compressed gas, deteriorating the efficiency of the scroll compressor.

SUMMARY OF THE INVENTION

The scroll compressor of the present invention has a stationary scroll and a slewing scroll in which scroll-like wraps raised from the respective end plates of the respective scrolls are engaged to each other to provide a compression space therebetween.

Then, fluid is inhaled, compressed, and discharged by using the circular orbit motion of the slewing scroll to allow the compression space to move from the outer periphery leading to an inhale opening to the center part leading to a discharge opening while reducing the capacity. At least any of side faces sliding to each other of the respective wraps has a machining mark parallel to the end plate. This face is a face cutting-machined by a non-rotational tool. A side face of the wrap perpendicular to the end plate has a shape of non-rotation obtained by Hale machining.

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BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a longitudinal sectional view illustrating a stationary scroll and a slewing scroll of a scroll compressor according to a first exemplary embodiment of the present invention.

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Fig. 2A is a longitudinal sectional view illustrating a method for machining the stationary scroll of a compressor in the first exemplary embodiment of the present invention.

Fig. 2B is a lateral sectional view illustrating swells in the longitudinal direction of the wrap of the compressor in the first exemplary embodiment of the present invention.

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Fig. 2C is a perspective view illustrating machining marks continuing in the longitudinal direction of the wrap of the compressor in the first exemplary embodiment of the present invention.

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Fig. 3A is a schematic sectional view illustrating a method for machining the stationary scroll of the compressor in the first exemplary embodiment of the present invention.

Fig. 3B illustrates a Hale machining tool seen from three directions that is a non-rotational tool for machining a side face of the wrap of the compressor in the first exemplary embodiment of the present invention.

5 Fig. 4A is a schematic view illustrating the surface roughness in the case of the machining by Hale machining in the first exemplary embodiment of the present invention.

Fig. 4B is a schematic view illustrating the surface roughness in the case of the machining by an end mill according to prior art.

10 Fig. 5 is a schematic sectional view illustrating the machining method of a stationary scroll of a compressor in a second exemplary embodiment of the present invention.

Fig. 6 is a schematic sectional view illustrating the machining method of a stationary scroll of a compressor in a third exemplary
15 embodiment of the present invention.

Fig. 7 is a schematic sectional view illustrating the machining method of a stationary scroll of a compressor in a fourth exemplary embodiment of the present invention.

20 Fig. 8 is a schematic sectional view illustrating the machining method of a stationary scroll of a compressor in a fifth exemplary embodiment of the present invention.

Fig. 9 is a schematic sectional view illustrating the machining method of a stationary scroll of a compressor in a sixth exemplary embodiment of the present invention.

25 Fig. 10 is a schematic sectional view illustrating the machining method of a stationary scroll of a compressor in a seventh exemplary embodiment of the present invention.

Fig. 11 is a sectional view illustrating the entire constitution of a sealed type scroll compressor in the respective embodiments of the present invention.

Fig. 12 is a lateral sectional view illustrating a stationary scroll and a slewing scroll showing a conventional scroll compressor and the machining method thereof.

Fig. 13 is a longitudinal sectional view illustrating the stationary scroll and the slewing scroll shown in Fig. 12.

10 DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Hereinafter, a scroll compressor and a method for machining the scroll wrap according to embodiments of the present invention will be described with reference to the drawings. Elements similar to those in a previous embodiment have the same reference marks as those in the previous embodiment, and details descriptions thereof are omitted.

FIRST EXEMPLARY EMBODIMENT

First, a scroll compressor according to a first exemplary embodiment of the present invention will be described with reference to Figs. 1 and 11. Stationary scroll (hereinafter referred to as scroll) 1 and slewing scroll (hereinafter referred to as scroll) 2 are shaped so that scroll-like wraps 1B and 2B are raised from end plates 1A and 2A so as to be substantially perpendicular to the end plates, respectively. Scrolls 1 and 2 are provided so that wraps 1B and 2B are engaged to each other to have compression space 3 therebetween. A capacity of compression space 3 is decreased by a circular orbit motion of scroll 2 while compression space 3 moves

from an outer circumference leading to inhale opening 4 to a center part leading to discharge opening 5. Thus, scroll compressor (hereinafter referred to as compressor) 6 inhales, compresses, and discharges fluid in such a manner.

5 Compressor 6 is stored in sealed container 7 together with motor 8 for driving scroll 2, thereby providing a maintenance-free compression apparatus for air-conditioning. Thus, fluid to be inhaled, compressed, and discharged is a cooling medium. However, the present invention is not limited to this and may have
10 any structure so long as the structure is provided so that a stationary scroll and a slewing scroll having scroll-like wraps are engaged to each other to provide a compression space to use the circular orbit motion of the slewing scroll to inhale, compress, and discharge fluid. Fluid to be handled is also not limited.

15 The inner periphery of sealed container 7 is fixed with stator 8A of motor 8. Rotator 8B of motor 8 corresponding to this is fixed to crank shaft 16 for driving scroll 2 of compressor 6. Main bearing member 18 and sub bearing member 20, which are fixed to the inner periphery of sealed container 7, axially support crank shaft
20 16 in a rotatable manner. Since the present exemplary embodiment shows the horizontal placement type one, main bearing member 18 and sub bearing member 20 axially support crank shaft 16. However, in the case of the vertical placement type one for example, crank shaft 16 also may be supported by one support. The lower
25 part of sealed container 7 is lubrication storage 17.

Scroll 1 is attached to main bearing member 18 by a bolt for example. Scroll 2 and main bearing member 18 have therebetween

Oldham's coupling 19 for preventing scroll 2 from rotating on its axis and for causing only a slewing motion (i.e., circular orbit motion) thereof. At the back face of scroll 2, there is provided slewing shaft 25 for driving the rotation that is inserted to eccentric bearing 26 in journal shaft 16A provided at one end of shaft 16. In accordance with the rotation of journal shaft 16A when crank shaft 16 is rotated, scroll 2 has a circular orbit motion via eccentric bearing 26 and slewing shaft 25. In sub bearing member 20, an end part of crank shaft 16 has oil feeding mechanism 27 and oil-sucking tube 27A is immersed in lubrication storage 17.

On the other hand, crank shaft 16 includes therein oil-feeding path 28. Crank shaft 16 drives oil feeding mechanism 27 and oil-sucking tube 27A sucks lubrication oil in lubrication storage 17. Then, lubrication oil lubricates the respective sliding parts of compressor 6 via oil-feeding path 28 and is discharged into sealed container 7. Thereafter, lubrication oil is sent through the clearance between motor 8 and sealed container 7 to return to oil-sucking tube 27A. The cooling medium inhaled by compressor 6 from inhale tube 29 is compressed in compression space 3 and is sent via discharge opening 5 and discharge tube 30 provided in sealed container 7, thereby being discharged out of sealed container 7.

In compressor 6 of the present exemplary embodiment, at least one of side faces 1C and 2D of the respective wraps 1B and 2B sliding to each other and at least one of side faces 1D and 2C of the respective wraps 1B and 2B consist of cutting-machined faces by Hale machining. For example, side faces 1C and 1D of wrap 1B of scroll 1 are Hale-machined by non-rotational tool 9 or the like shown

in Figs. 2A, 3A and 3B. Non-rotational tool 9 shown in Figs. 3A and 3B are a Hale tool in which, when the cutting face cuts a material to be cut, the cutting face is moved relative to the material to be cut so as to be substantially perpendicular to the direction along which the cutting is performed. Machining processes other than this are not particularly limited. In other words, metal material such as iron and aluminum is basically formed by a casting or the like and cutting-machined by an end mill, subsequently finished by the Hale machining with non-rotational tool 9 or the like. Alternatively, the cutting machining by the end mill may be omitted.

In this manner, at least one of side faces 1C and 2D of scroll-like wraps 1B and 2B sliding to each other and at least one of side faces 1D and 2C of scroll-like wraps 1B and 2B sliding to each other are finished by Hale machining. An example is shown in Fig. 2B in which side faces 1C and 1D of wrap 1B of scroll 1 are Hale-machined and side faces 2C and 2D are not finished by Hale machining but are finished by an end mill. By providing the structure as described above, side faces 1C and 1D have no swell in the longitudinal direction or, even in a case where such a swells are caused, the swells will be much smaller than that caused in side faces 2C and 2D. In the case of a polishing-machining by an end mill, the machining conditions change in a cyclic manner depending on a part having a blade and a part having no blade. Furthermore, the polishing-machining by an end mill causes uneven machining because of the eccentric motion of the tool depending on an accuracy with which the tool is attached or the rotation accuracy of a machine for the machining. In contrast, Hale machining does not cause such

uneven machining. In the case of the machining by a non-rotational tool, a polishing-machined side face does not have a swell in the longitudinal direction due to the eccentricity, even when the tool is attached with a slight inclination.

5 Furthermore, a surface finished by Hale machining has a fine texture. Thus, if one of side faces 1C and 2D and one of side faces 1D and 2C are Hale-machined respectively, both wraps 1B and 2B do not have therebetween such a clearance all over the sliding area in the direction along which they are raised that may cause the
10 leakage of compressed gas. As a result, the leakage of compressed gas as described above is prevented, improving the compression efficiency.

As described above, the side faces of wraps 1B and 2B that are Hale-machined have little or no swell at the periphery and the
15 side faces of wraps 1B and 2B have a smooth surface. As a result, scroll 2 has a circular orbit motion without having a minute vibration during the operation. Thus, a scroll compressor can be obtained whose operation noise is lower than that of the conventional one. Furthermore, abrasion is also reduced.

20 As shown in Fig. 4B, the machining by an end mill causes a surface roughness of $2\mu\text{m}$. On the other hand, the surface roughness caused by the finishing by Hale machining is $1\mu\text{m}$ as shown in Fig. 4A, which is a half of $2\mu\text{m}$. Furthermore, convex 22 of a surface roughness by Hale machining is less sharp than that of
25 convex 21 of a surface roughness by the machining by an end mill. This almost solves the possibility of abrasion starting from a local fusion due to heat caused by the contact of convexes, thus reducing

the sliding resistance to improve the abrasion resistance. Furthermore, concave 22A of a surface roughness by Hale machining is smaller than concave 21A by the machining by an end mill. Thus, the leakage of compressed gas can be suppressed more
5 effectively. In this manner, a highly-reliable scroll compressor is obtained.

Therefore, the structure as described above is convenient when the maintenance free sealed type scroll compressor as shown in Fig. 11 guarantees the function for a long period of time, 10 years,
10 for example. It is more preferable that both of side faces 1C and 2D sliding to each other and both of side faces 1D and 2C sliding to each other are Hale-machined as described above.

An example of the method of Hale machining for scroll-like wraps 1B and 2B as described above is shown in Fig. 2A.
15 Non-rotational tool 9 is chucked to the tip end of machining shaft 11 whose movement is controlled. This assembly is used as a non-rotational cutting tool so that center axis line 12 of non-rotational tool 9 is parallel to center axis line 13 of scrolls 1 and 2. In this status, non-rotational tool 9 is moved along the
20 longitudinal direction of wraps 1B and 2B while being set to the subjects to be Hale machined of the wraps such as side face 1C. In this manner, Hale machining by non-rotational tool 9 is performed. However, a specific method for performing Hale machining can be selected freely. The surface roughness caused by Hale machining
25 is preferably suppressed to be equal to or lower than $1\mu\text{m}$ in order to take the advantage by Hale machining as described above.

As shown in Figs. 2A and 3A, length L of non-rotational tool

9 is preferably longer than raised part height H of wraps 1B and 2B whose side faces are Hale-machined. When non-rotational tool 9 as described above is used, non-rotational tool 9 can be set at any point within raised part height H of wraps 1B and 2B. Thus, only
5 moving non-rotational tool 9 in the longitudinal direction of wraps 1B and 2B to be Hale machined can provide the machine-finishing of the shape of the side face of the scroll to be Hale machined. This eliminates the time and adjustment required when a cutting machining process is divided to a plurality of steps. As a result, the
10 machining accuracy is increased and the machining time is reduced, providing a low-cost scroll compressor.

When the machining as described above is performed, the machine-finishing by non-rotational tool 9 is performed such that non-rotational tool 9 does not move back and forth in the direction
15 of tool center axis line 12. As a result, microscopic concavity and convexity as shown in Fig. 2C are caused in the direction perpendicular to end plates 1A and 2A along which wraps 1B and 2B are raised. Specifically, machining marks 31 are formed in a direction along which non-rotational tool 9 is moved relative to the
20 side faces of wraps 1B and 2B to be Hale-machined by non-rotational tool 9 so that machining marks 31 are continued along the longitudinal direction of wraps 1B and 2B. Machining marks 31 as described above significantly reduce the swells caused at the Hale-machined side faces of wraps 1B and 2B in the longitudinal
25 direction. Thus, scroll 2 is in slewing motion or has a circular orbit motion with scroll 1 without having a minute vibration, thus providing a scroll compressor having reduced noise.

In many cases, machining marks 31 as described above are obtained by transferring the shape the blade of non-rotational tool 9 at its side face. Thus, machining mark 31 can be formed to have an arbitrary shape by shaping the blade of non-rotational tool 9 at the side face. In order to sufficiently realize the characteristics of Hale machining as described above, although any method for machining a substrate may be used, an amount of a finishing allowance for Hale machining is required that is not influenced by the condition of the substrate face. Furthermore, a determined finishing allowance is preferably machined by one Hale machining operation as described above.

SECOND EXEMPLARY EMBODIMENT

Fig. 5 is a schematic sectional view illustrating a method for machining a stationary scroll in a second exemplary embodiment of the present invention. In the present exemplary embodiment, the shape of the blade of non-rotational tool 9 at its side face is managed as required by the polishing machining of the blade for example. The shape is used to machine wrap 1B or the like so that the shape of the blade is transferred in the direction along which side faces 1C and 1D to be Hale machined of stationary scroll 1 are raised i.e., a direction perpendicular to end plate 1A. By the machining so, the shape of the side face of wrap 1B or the like perpendicular to end plate 1A, i.e., the shape in the direction of center axis line 13, can be managed by the shape management of non-rotational tool 9. Wrap 1B or the like of stationary scroll 1 is Hale-machined. As a result, the shape is optimally provided while being applied with heat and

pressure during the operation in an easy and stable manner. This reduces the leakage of compressed gas during the operation, providing a highly efficient scroll compressor.

Machining mark 31 as described above is also achieved by a cutting machining by non-rotational tool 9 other than Hale machining, for example, by a grind stone. Thus, the effect for reducing the swell in the longitudinal direction of wraps 1B and 2B depending on the status of machining mark 31 is achieved regardless of the difference of a machining method.

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THIRD EXEMPLARY EMBODIMENT

Fig. 6 is a schematic sectional view illustrating a method for machining a stationary scroll in a third exemplary embodiment of the present invention. In the present exemplary embodiment, each of corner parts 1E at boundary parts between side faces 1C and 1D of wrap 1B of stationary scroll 1 and end plate 1A thereof has a curved surface.

Spaces 34 are provided between inner and outer chamfered corner parts 33 at the tip end of wrap 2B in slewing scroll 2 and corner parts 1E of stationary scroll 1. Spaces 36 are also provided between corner parts 2E of slewing scroll 2 having no curved surfaces and inner and outer chamfer parts 35 at the tip end of wrap 1B in stationary scroll 1. By providing corner part 1E with a curved surface, space 34 is several times smaller than space 36. Thus, the leakage of compressed gas through space 34 is reduced, providing a scroll compressor having high compression efficiency. Although the case where the structure as described above is applied

to stationary scroll 1 is provided in the present exemplary embodiment as a typical example, the structure also may be preferably applied to slewing scroll 2.

5 FOURTH EXEMPLARY EMBODIMENT

Fig. 7 is a schematic sectional view illustrating a method for machining a stationary scroll in a fourth exemplary embodiment of the present invention. In the present exemplary embodiment, stationary scroll 1 to be polished is fixed on chucking table 42 by
10 chucking apparatus 41. In this chucking, at least two positions at the periphery of stationary scroll 1 are chucked and fixed by chucking member 43. While being in this condition, a predetermined uniform cutting-machined face is obtained out of a substrate by a casting or the like by cutting-machining with end mill
15 44 in an amount of the cutting allowance. Thereafter, stationary scroll 1 is Hale-machined by non-rotational tool 9 without being detached from chucking apparatus 41 and while being chucked as in the case of the machining by end mill 44.

As a result, even when finishing allowance 70 in Hale
20 machining by non-rotational tool 9 is reduced to about 0.01mm, the remainder of previously-machined face 45 that is a substrate cutting-machined by end mill 44 can be eliminated. Thus, a component having a high quality is obtained. Wrap 1B in particular frequently has a complicated shape, for example, an
25 involute shape. Due to this reason, if wrap 1B is once detached from chucking apparatus 41 prior to a finishing step, the center or angle is dislocated. In this case, if finishing allowance 70 is smaller

than about 0.05mm, previously-machined face 45 remains, causing a defective quality. As stationary scroll 1 is Hale-machined without being detached from chucking apparatus 41, finishing allowance 70 is uniform to stabilize the load to non-rotational tool 9, thus providing a steady machining accuracy. Finishing allowance 70 is also minute and thus the load to non-rotational tool 9 is small, thus providing a long service life to non-rotational tool 9. As a result, a scroll compressor having a high quality and a low cost is obtained. Although the case where the method as described above is applied to stationary scroll 1 is provided in the present exemplary embodiment as a typical example, the method also may be preferably applied to slewing scroll 2.

FIFTH EXEMPLARY EMBODIMENT

Fig. 8 is a schematic sectional view illustrating a method for machining a stationary scroll in a fifth exemplary embodiment of the present invention. In the present exemplary embodiment, side faces 1C and 1D of wrap 1B and a face of end plate 1A in stationary scroll 1 are simultaneously Hale-machined and finished by non-rotational tool 9. The bottom part of non-rotational tool 9 has a minute curved surface corresponding to corner parts 1E provided at boundary parts between side faces 1C and 1D of wrap 1B and end plate 1A. Thus, each of corner parts 1E is provided to have a minute curved surface, thus improving the strength of wrap 1B. This provides a highly-reliable scroll compressor. Although the case where the method as described above is applied to stationary scroll 1 is provided in the present exemplary embodiment as a

typical example, the method also may be preferably applied to slewing scroll 2.

SIXTH EXEMPLARY EMBODIMENT

5 Fig. 9 is a schematic sectional view illustrating a method for machining the stationary scroll in a sixth exemplary embodiment of the present invention. In the present exemplary embodiment, side faces 1C and 1D of wrap 1B and face 1F of end plate 1A in stationary scroll 1 are finished and machined by Hale-machining by
10 separate steps as shown by the solid line and the phantom line by the same non-rotational tool 9.

As shown in Fig. 3B, the machining face of non-rotational tool 9 are divided to the two parts of side face cutting blade 9B for wrap 1B and tip end face cutting blade 9C for end plate 1A. This
15 divided structure suppresses the load during the machining from being accumulated while providing the machining by the two faces of non-rotational tool 9, thus providing a longer service life to non-rotational tool 9.

The above effect also can be provided by the separate
20 machinings by two exclusive non-rotational tools for machining wrap 1B and machining end plate 1A, respectively. Although the case where the method as described above is applied to stationary scroll 1 is provided in the present exemplary embodiment as a typical example, the method also may be preferably applied to
25 slewing scroll 2.

SEVENTH EXEMPLARY EMBODIMENT

Fig. 10 is a schematic sectional view illustrating a method for machining a stationary scroll in a seventh exemplary embodiment of the present invention. In the present exemplary embodiment, when wrap 1B of stationary scroll 1 is Hale-machined, inner face 1C is firstly machined by non-rotational tool 9 as shown by the solid line. Thereafter, outer face 1D is machined by non-rotational tool 9 that is the same as that used for inner face 1C as shown by chain double-dashed line. As a result, both of the inner face and outer face of can be finished, while the same chucking status as that in the fourth exemplary embodiment is maintained, by the same non-rotational tool 9 to have optimal scroll shapes, respectively. This provides a highly efficient scroll compressor. When at least one of side faces 1C and 2D sliding to each other and at least one of side faces 1D and 2C are Hale-machined, the inner face and outer face of wrap 1B of scroll 1 are Hale-machined. Thus, operations for attaching and detaching a work (chucking apparatus) and non-rotational tool 9 and for adjusting the relative positions are eliminated, improving the operation efficiency. Although the case where the method as described above is applied to stationary scroll 1 is provided in the present exemplary embodiment as a typical example, the method also may be preferably applied to slewing scroll 2.

INDUSTRIAL APPLICABILITY

According to the present invention, the side face of a wrap has no or small swells by Hale machining in the longitudinal direction. Furthermore, the surface by Hale machining has a

minute texture. Thus, the leakage of compressed gas is prevented from being caused at side faces sliding to each other of the respective wraps of a stationary scroll and a slewing scroll, improving the compression efficiency. Furthermore, the swells in
5 the periphery direction of the side face of the wrap are small and have a smooth texture. As a result, the slewing scroll has a circular orbit motion during the operation without having a minute vibration. This provides a quieter scroll compressor that has smaller operation noise than that of the conventional design. The machining by a
10 non-rotational tool also eliminates the need for a spindle apparatus for rotating the tool. As a result, the cost for operating the machinery in a plant or for purchasing equipment can be reduced, thus lowering the cost for producing the scroll compressor.

It is noted that the respective characteristics of the present
15 invention can be used separately or in various combinations in a possible range.